

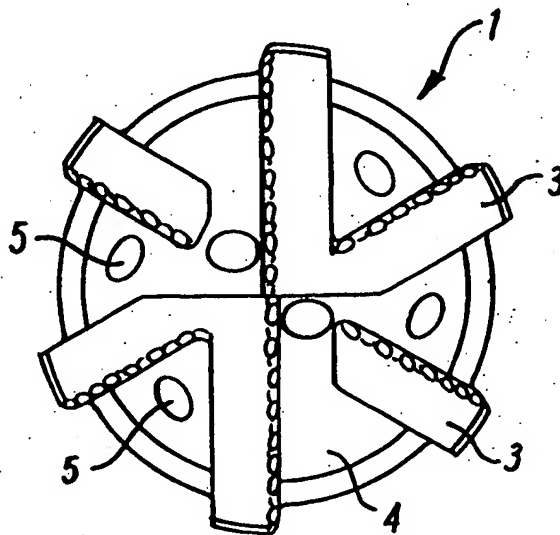


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(54) Title: A DRILLING TOOL**(57) Abstract**

A casing drilling shoe (1) is disclosed which is adapted for attachment to a casing string and comprises an outer drilling section (2) constructed of a relatively hard material such as steel and an inner section (4) constructed of a readily drillable material such as aluminium. The drilling shoe further includes a means (7) for controllably displacing the outer drilling section to enable the shoe to be drilled through using a standard drill bit and subsequently penetrated by a reduced diameter casing string or liner.



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A DRILLING TOOL

The invention has an application particularly, but not exclusively, in relation to the exploration for oil and gas. More specifically, the present invention concerns a casing drilling shoe primarily for use in oil well drilling.

When drilling subterranean formations for the purpose of oil exploration it is normal to firstly drill a section of hole of a particular diameter and then remove the drill bit from the well bore. A tubular member of lesser diameter, known as casing, is placed in the well bore and subsequently the annulus between the drilled hole and the outside of the casing is filled with cement. The purpose of the cement is to isolate certain of the subterranean strata from each other. The next operation is to pass through the casing with a smaller diameter drill bit and drill the further section of hole beyond the previously attained depth. This sequence is repeated as many times as necessary, with smaller and smaller components, until the ultimate desired depth of the well is achieved.

1 Positioned at the end of each casing string is a rounded
2 guiding component known as a shoe. Typically, the
3 leading edge of the shoe is constructed from cement, to
4 enable it to be easily drilled through by the next drill
5 bit.

6
7 The cost of oil exploration particularly in offshore
8 regions is extremely high. For instance, the operating
9 cost of a semi-submersible drill rig is often in excess
10 of \$100,000 per day (June 1998). Thus it is in the
11 interest of the operator to minimise the time taken to
12 drill a well. At great depths, the round trip time to
13 pull out a drill bit and replace it with another one can
14 be many hours. This "trip" time is seen as non-
15 productive and wasteful, and a significant advantage can
16 be gained, if, having drilled to target depth the drill
17 bit did not have to be removed from the well bore. In
18 this way, a trip could be saved.

19
20 A proposed solution would be to attach the drill bit to
21 the leading end of the casing string and drill to target
22 depth and then cement the casing. Certain advances in
23 recent years have rendered this solution more viable,
24 including the provision of premium casing threads able to
25 take the necessary drilling torque, and rotary top drives
26 able to transmit the torque directly to the trailing end
27 of a drill string are commonplace.

28
29 However, technical difficulties have not entirely been
30 overcome and this is clearly evidenced by the fact that
31 the industry has not adopted "drilling with casing" to
32 date.

33

1 One major remaining issue concerns the drill bit itself.
2 By design drill bits are robust devices able to withstand
3 the rigours of a downhole environment. They are
4 generally made from hard materials such as steel or
5 tungsten carbide matrix. After cementing the drilled-in
6 casing the subsequent drill bit would have to pass
7 through the previous one before exiting the end of the
8 casing string. Unfortunately, modern drill bits
9 optimised for rock removal are unable to drill through
10 the materials from which they themselves are constructed
11 without sustaining a level of damage which would render
12 the task of drilling the next section of rock formation
13 impossible. It is possible to drill through a drill bit
14 with special tools known as mills, but these tools are
15 unable to penetrate rock formations effectively and so
16 the mill would have to be "tripped" from the hole and
17 replaced with a drill bit. In this case, the trip saving
18 advantage gained by drilling with casing would have been
19 lost.

20

21 Thus it is recognised in the present invention that
22 considerable advantage is to be gained in the provision
23 of a casing shoe that is able to drill rock formations
24 effectively, but which itself is capable of being drilled
25 by standard oilfield drill bits.

26

27 Drilling shoes have been available in the past
28 specifically for attachment to casing, although usually
29 for special applications such as a situation where the
30 lowermost rock strata of a section of a well to be
31 drilled are extremely unconsolidated and there is a
32 consequential risk that after the drill bit is removed
33 from the well the rock strata may collapse into the well
34 bore. This then renders the process of placing the casing

1 in the well bore difficult or impossible. Such casing
2 shoes have invariably been made from the hard materials
3 associated with normal drill bits and as such cannot be
4 drilled through.

5
6 Also, casing whilst drilling systems have been and
7 continue to be available to the industry. One such
8 system involves running a casing string and a drill
9 string in tandem. Attached to the leading end of the
10 casing string is a core type bit able to cut a "kerf" of
11 formation. Positioned at the leading end of the drill
12 string is a drill bit driven by a hydraulic motor. Thus,
13 the core bit and the drill bit together can drill a hole
14 of the required diameter. Prior to performing the
15 cementing operation however, the drill bit has to be
16 removed from the well bore and thus the expensive trip is
17 not saved.

18
19 Probably the apparatus which comes closest to overcoming
20 the afore-described problems is known as a reamer shoe.
21 Reamer shoes have become available over the last few
22 years and are devices that are able to drill over the
23 extreme outer diameter of the tool but which have an
24 inner section manufactured from a material which is
25 drillable with drill bits. The objective or utility of
26 these tools, however, is to help the casing string enter
27 a difficult well bore and when landed and cemented, pose
28 no obstruction to the subsequent drill bit.

29
30 According to the present invention there is provided a
31 casing drilling shoe adapted for attachment to a casing
32 string, wherein the shoe comprises an outer drilling
33 section constructed of a relatively hard material and an
34 inner section constructed of a readily drillable

1 material, and wherein means is provided for controllably
2 displacing the outer drilling section to enable the shoe
3 to be drilled through using a standard drill bit and
4 subsequently penetrated by a reduced diameter casing
5 string or liner.

6

7 Optionally, the outer section may be made of steel and
8 the inner section may be made of aluminium.

9

10 Preferably, the outer section is provided with one or
11 more blades, wherein the blades are moveable from a first
12 or drilling position to a second or displaced position.
13 Preferably, when the blades are in the first or drilling
14 position they extend in a lateral or radial direction to
15 such extent as to allow for drilling to be performed over
16 the full face of the shoe. This enables the casing shoe
17 to progress beyond the furthest point previously attained
18 in a particular well.

19

20 The means for displacing the outer drilling section may
21 comprise of a means for imparting a downward thrust on
22 the inner section sufficient to cause the inner section
23 to move in a down-hole direction relative to the outer
24 drilling section. The means may include an obturating
25 member for obstructing the flow of drilling mud so as to
26 enable increased pressure to be obtained above the inner
27 section, the pressure being adapted to impart the
28 downward thrust.

29

30 Typically, the direction of displacement of the outer
31 section has a radial component.

32

33 Also according to the invention there is provided a
34 casing drilling shoe adapted for attachment to a casing

1 string, wherein the shoe comprises an outer drilling
2 section constructed of a relatively hard material and an
3 inner section constructed of a readily drillable
4 material, and wherein means is provided for controllably
5 displacing the outer drilling section to a position
6 whereby it does not interfere with subsequent drilling
7 through the shoe for the placement of further casing or a
8 liner down-hole.

9
10 An embodiment of the invention will now be described by
11 way of example only and with reference to the
12 accompanying Figures, in which:

13
14 Figure 1 is an end view of a drill casing shoe or
15 tool in accordance with the invention;

16
17 Figure 2 shows a sectional view in elevation of a
18 tool of Figure 1 attached to the end of a casing
19 string;

20
21 Figure 3 shows the tool in its normal drilling mode;
22 and

23
24 Figures 4 and 5 show the tool in respective further
25 stages activated and ready for cementing and
26 subsequent drilling.

27
28 Referring firstly to Figures 1 and 2, a drilling shoe is
29 generally depicted at 1. The drilling shoe 1 has an
30 outer drilling section 2 having blades 3. The blades 3
31 are made of a hard material such as steel which may
32 incorporate a cutting structure of polycrystalline
33 diamond or tungsten carbide for example. They may be of

1 industry standard type and or designed to suit particular
2 formations to be drilled by the tool.

3

4 In Figures 1 and 2, the outer drilling section 2 is in
5 the drilling mode and, as such, the shoe 1 is incapable
6 of being drilled through by standard drill bits.

7

8 The tool 1 is further provided with an inner section 4
9 which, in the embodiment shown, comprises a generally
10 cylindrical member having ports 5 in its lower region to
11 allow for the passage of drilling mud to the end or
12 drilling face of the tool or shoe 1. The ports 5
13 communicate via feed passages 8 with a single circular
14 bore 6, the bore 6 providing a circulation path for
15 drilling mud or lubricant. The tool 1 is also provided
16 with an anti-rotation pin 14 to prevent the inner section
17 spinning when being drilled out.

18

19 Notably, the bore 6 is adapted to be obstructed or
20 blocked. For example, the bore 6 in the example
21 embodiment includes a ball seat 7 such that upon dropping
22 a ball sized to land on the seat 7, the bore 6 becomes
23 obstructed enabling an operator to pressure-up behind the
24 bore. It will be known to persons skilled in the art
25 that other methods may be employed for this purpose, such
26 as dropping darts and so on.

27

28 As may be seen in Figure 3, the inner section 4 is
29 captured between the blades 3 of the outer drilling
30 section and, at its upper end, a locking ring 9.

31

32 In use, when the tool 1 is in its drilling mode, drilling
33 mud may be pumped down the inside of the casing, through
34 the bore 6 and subsequently through the ports 5 in the

1 inner section 4. The mud, while providing a lubricant,
2 also serves to clean the face of the tool and is able to
3 return up the annulus between the casing and the well
4 bore (not shown). During this process, there would be a
5 small downward thrust on the inner section 4 due to the
6 pressure drop of the mud passing through the ports 5.
7 This thrust would not be sufficient to displace the
8 blades 3 of the outer section 2 relative to the rest of
9 the tool 1.

10

11 However, when the drilling process is complete, it is a
12 feature of this invention that the tool or shoe may be
13 manipulated or activated to render it drillable.
14 Activation may be achieved by applying a relatively large
15 downward thrust to the inner portion 4.

16

17 In the example embodiment illustrated in the accompanying
18 Figures, the downward thrust results from blocking the
19 bore 6 or flow passages 8 feeding the ports 5 by landing
20 a ball 10 on the rest 7 (see Figure 4). The ball 10 may
21 be dropped from surface or, preferably, may be released
22 from a remotely actuated mechanism positioned just above
23 the tool 1. Again, methods of achieving remote ball
24 release are known to persons skilled in the art and
25 include, for example, increasing the flow rate of the
26 drilling mud or circulation fluid to a level whereby a
27 support for the ball in its mechanism is overcome. These
28 and other ball release subs are known in the industry.

29

30 After the ball 10 is seated, pump pressure rises and the
31 downward thrust load on the inner section 4 increases.
32 This thrust load is transferred to the blades 3
33 positioned at the leading end of the tool 1. The design
34 of the blades 3 is such that they can be displaced by a

1 predetermined load, well below the maximum safe pressure
2 that the casing can withstand. When this load is reached
3 the blades 3 are displaced outwardly in the manner of
4 downward pointing fingers, while the inner section 4
5 advances downwardly until its motion is arrested by
6 mating shoulder portions 11 of the inner and outer
7 sections 2,4. In Figure 4 the inner section 4 has been
8 fully displaced.

9
10 It is to be further noted that the outer section 2 is
11 provided with ports 12. In the normal drilling mode, the
12 ports 12 are obstructed by the sleeve 13 as circulation
13 is enabled via the ports 5. However, as may be seen in
14 Figure 4, the fluid communication ports 12 are caused to
15 open, that is become unobstructed as the sleeve 13
16 travels down with the inner section 4 under the influence
17 of the downward thrust. This fulfils the necessary
18 requirement of re-establishing circulation at this point,
19 since the cementing operation involves pumping the cement
20 slurry down the inside of the casing and displacing it
21 into the annulus. An added advantage lies in the fact
22 that the operators of the tool are given a clear signal
23 that the tool has activated properly since on opening the
24 ports 12 the pressure level will fall significantly.

25
26 In Figure 4, it can be seen that the components that
27 rendered the tool incapable of being drilled have now
28 been displaced to a position where they will not
29 interfere with the next drill bit to be used.

30
31 Cementing of the casing may then be undertaken and after
32 the cement has set hard, drilling the next of hole
33 section may commence. This would typically involve
34 passing a drill bit of appropriate diameter through the

1 centre of the casing string and performing a drilling out
2 operation of the inner section 4. As the inner section is
3 made of a readily drillable material, such as aluminium,
4 this does not present any of the difficulties encountered
5 in the past. In Figure 5, the tool is shown after the
6 drilling-out operation has been completed, it is clear
7 from this view that the bit (which is not shown) is only
8 required to progress through components that were
9 constructed from drillable materials.

10

11 By the use of this tool it has been shown that a
12 significant advantage can be obtained and that major cost
13 savings can be released. In particular, the present
14 invention negates the requirement of having to retrieve
15 the drill string and drill bit before cementing the
16 casing. The invention further negates or at least
17 mitigates any requirement for milling. Importantly, the
18 tool incorporates a mechanism which when activated allows
19 the tool to be drilled through with a conventional
20 oilfield drill bit without causing damage to said bit.

21

22 It should be appreciated herein that the described and
23 illustrated apparatus and method is only one of many
24 possible techniques. Further modifications and
25 improvements may be incorporated without departing from
26 the scope of the invention herein intended.

1 **CLAIMS:**

- 2
- 3 1. A casing drilling shoe adapted for attachment to a
- 4 casing string, wherein the shoe comprises an outer
- 5 drilling section constructed of a relatively hard
- 6 material and an inner section constructed of a readily
- 7 drillable material, and wherein means is provided for
- 8 controllably displacing the outer drilling section to
- 9 enable the shoe to be drilled through using a standard
- 10 drill bit and subsequently penetrated by a reduced
- 11 diameter casing string or liner.
- 12
- 13 2. A drilling shoe as claimed in Claim 1, wherein the
- 14 outer section is made of steel and the inner section
- 15 may be made of aluminium.
- 16
- 17 3. A drilling shoe as claimed in Claim 1 or Claim 2,
- 18 wherein the outer section is provided with one or more
- 19 blades, wherein the blades are moveable from a first or
- 20 drilling position to a second or displaced position.
- 21
- 22 4. A drilling shoe as claimed in Claim 3, wherein when the
- 23 blades are in the first or drilling position they
- 24 extend in a lateral or radial direction to such extent
- 25 as to allow for drilling to be performed over the full
- 26 face of the shoe.
- 27
- 28 5. A drilling shoe as claimed in any one of the preceding
- 29 Claims, wherein displacing means for displacing the
- 30 outer drilling section comprises of a thrust means for
- 31 imparting a downward thrust on the inner section
- 32 sufficient to cause the inner section to move in a
- 33 down-hole direction relative to the outer drilling
- 34 section.

- 1 6. A drilling shoe as claimed in any one of the preceding
2 Claims, where the displacing means includes an
3 obturating member for obstructing the flow of drilling
4 mud so as to enable increased pressure to be obtained
5 above the inner section, the pressure being adapted to
6 impart the downward thrust.
7
- 8 7. A drilling shoe as claimed in any one of the preceding
9 Claims, wherein the direction of displacement of the
10 outer section has a radial component.
11
- 12 8. A casing drilling shoe adapted for attachment to a
13 casing string, wherein the shoe comprises an outer
14 drilling section constructed of a relatively hard
15 material and an inner section constructed of a readily
16 drillable material, and wherein means is provided for
17 controllably displacing the outer drilling section to a
18 position whereby it does not interfere with subsequent
19 drilling through the shoe for the placement of further
20 casing or a liner down-hole.

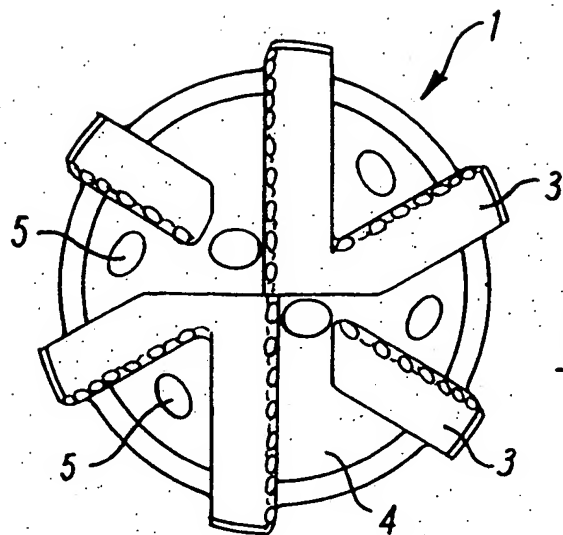


FIG. 1

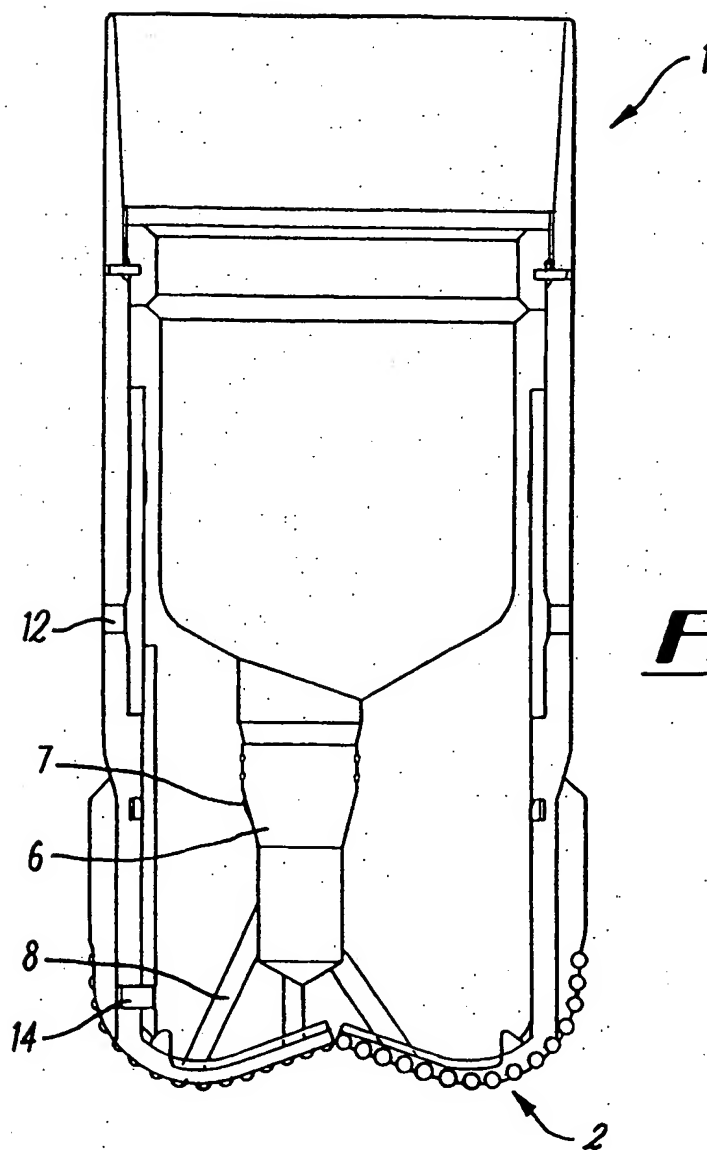


FIG. 2

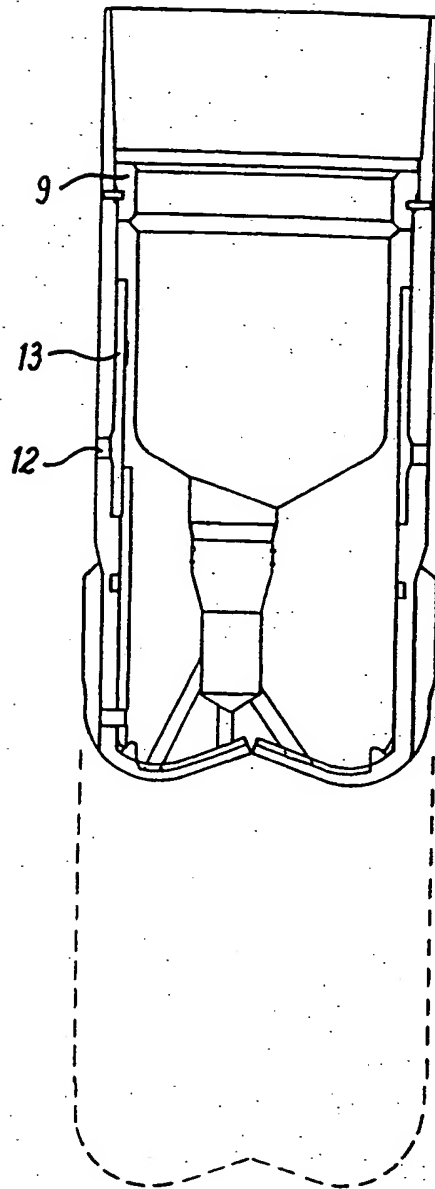


FIG. 3

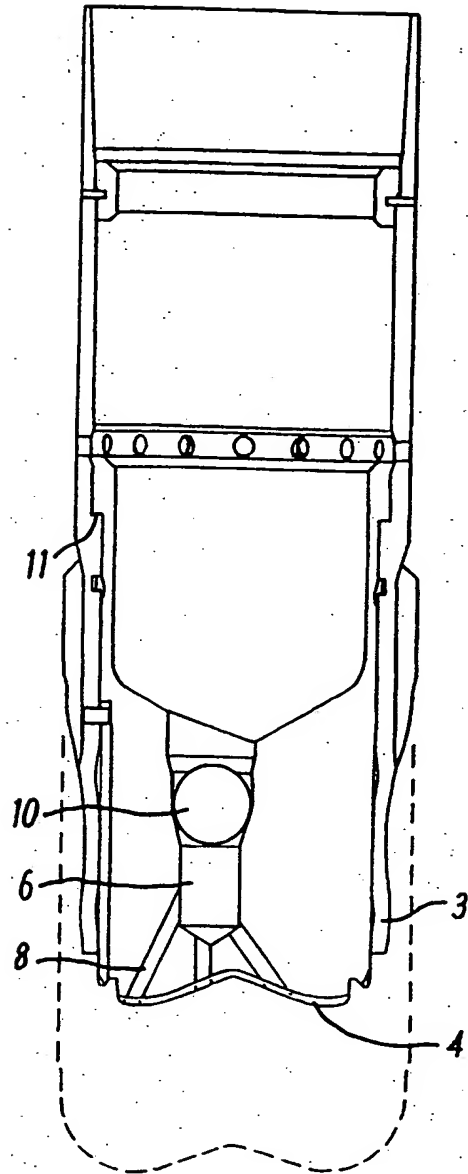


FIG. 4

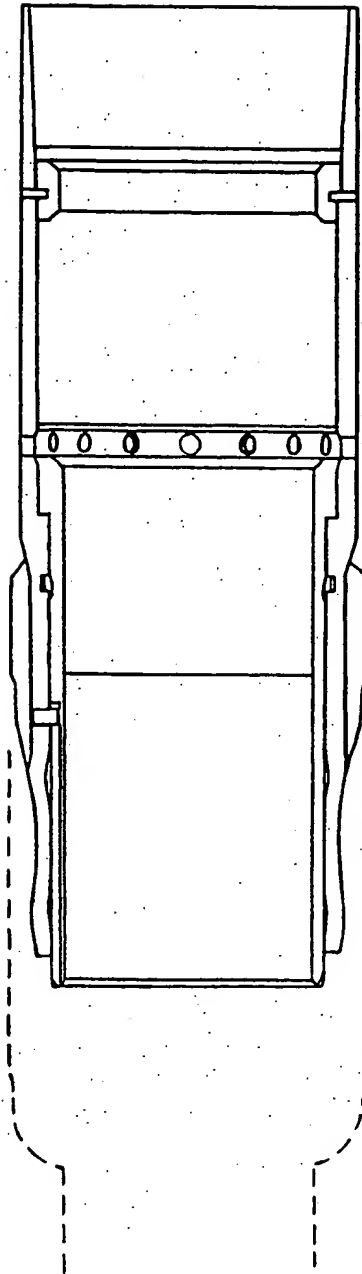


FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No

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A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 E21B7/20 E21B10/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 28635 A (BRIT BIT LIMITED ;STRONG PHILLIP (GB); WARDLEY MICHAEL (GB)) 19 September 1996 (1996-09-19) page 7, line 30 -page 8, line 34	1-4,7,8
Y	page 10, line 28 -page 11, line 9; claims 3,4,13,23; figures 3,4	5,6
Y	US 5 127 482 A (RECTOR JR CLARENCE A) 7 July 1992 (1992-07-07) column 4, line 26 - line 45; figures 4,5	5,6
A	GB 2 170 528 A (SEABOURN ED OSCAR) 6 August 1986 (1986-08-06)	
A	US 2 940 731 A (POOLE, M.L.) 14 June 1960 (1960-06-14)	

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Date of the actual completion of the international search

18 October 1999

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9628635 A	19-09-1996	AT 174403 T AU 4950396 A CA 2214749 A DE 69601129 D EP 0815342 A NO 974181 A	15-12-1998 02-10-1996 19-09-1996 21-01-1999 07-01-1998 05-11-1997
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